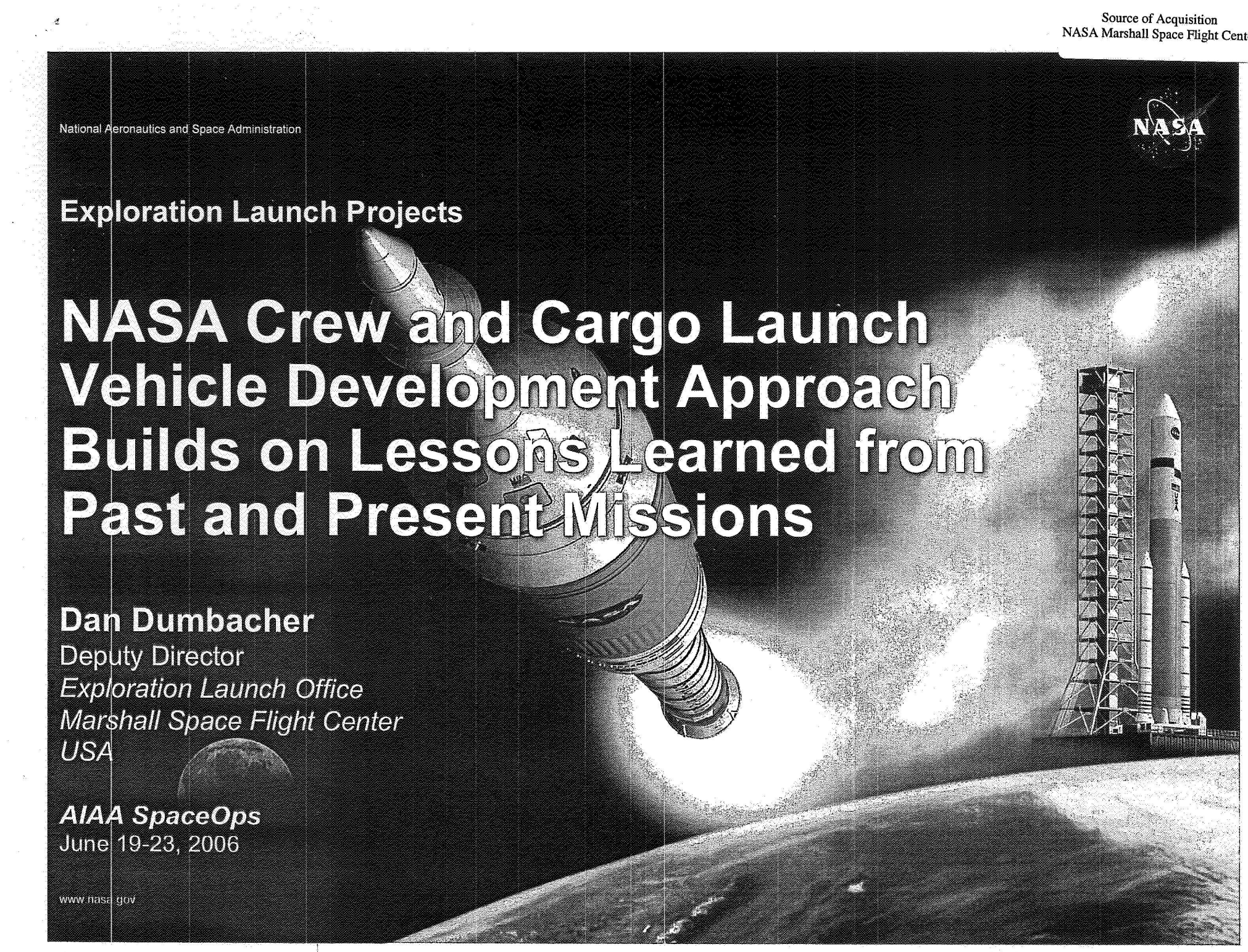
Source of Acquisition
NASA Marshall Space Flight Center

National Aeronautics and Space Administration

NASA

## Exploration Launch Projects

# NASA Crew and Cargo Launch Vehicle Development Approach Builds on Lessons Learned from Past and Present Missions



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***AIAA SpaceOps***
June 19-23, 2006

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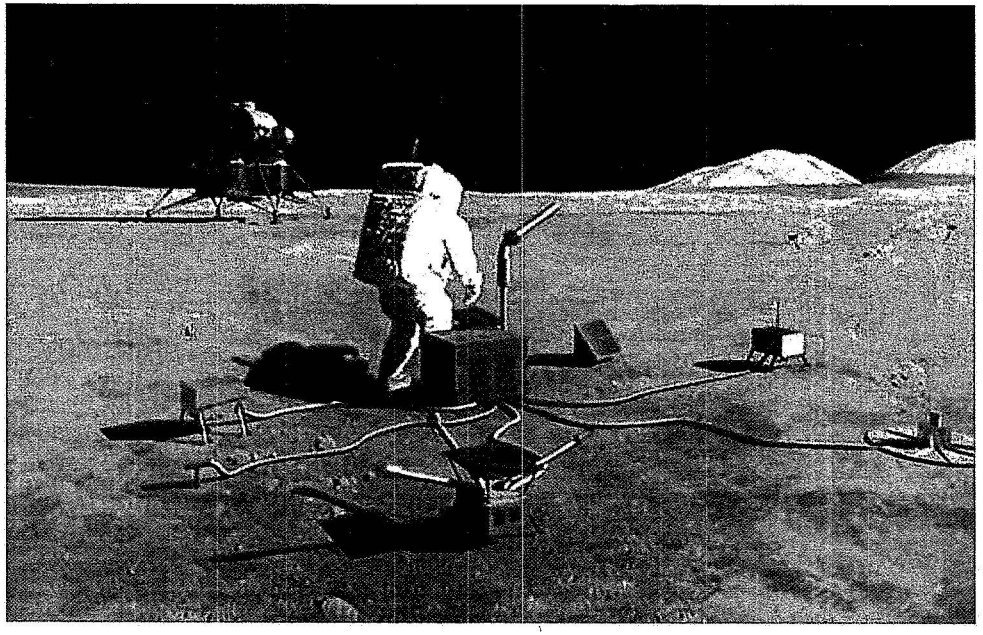
# Agenda



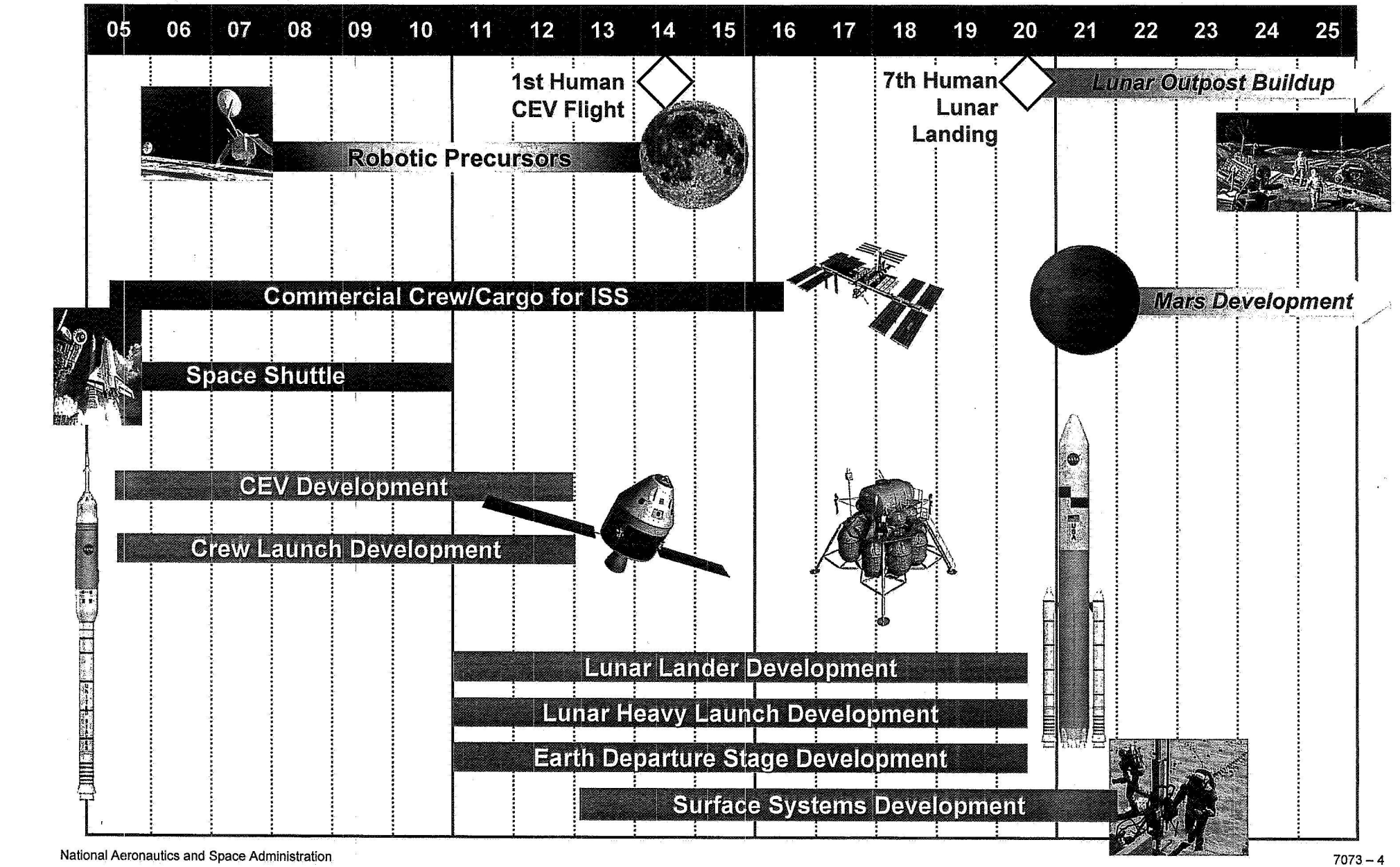

- U.S. Vision for Space Exploration
- NASA's Exploration Road Map
- The Moon — The First Step to Mars and Beyond
- Building on a Foundation of Proven Technologies
- Constellation Launch Vehicle Elements
- 1.5 Launch Earth Orbit/Lunar Orbit Rendezvous
- The Journey Continues
- Design Philosophy for Mission Success
- Lessons Learned: Implementation Tenets
- Lessons Learned: Early Integration with the Operators
- Summary
- For More Information

# The U.S. Vision for Space Exploration

- Complete the International Space Station
- Safely fly the Space Shuttle until 2010
- Develop and fly the Crew Exploration Vehicle no later than 2014 (goal of 2012)
- Return to the Moon no later than 2020
- Extend human presence across the solar system and beyond
- Implement a sustained and affordable human and robotic program
- Develop supporting innovative technologies, knowledge, and infrastructures
- Promote international and commercial participation in exploration

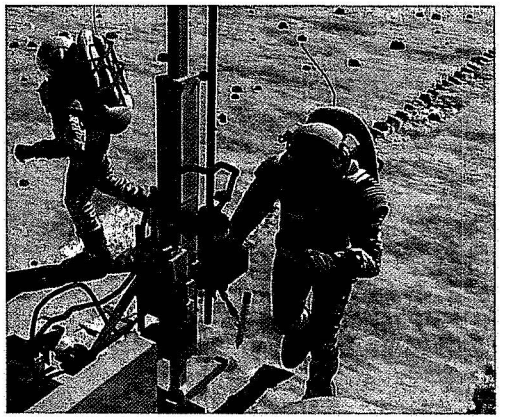


# NASA'S Exploration Roadmap

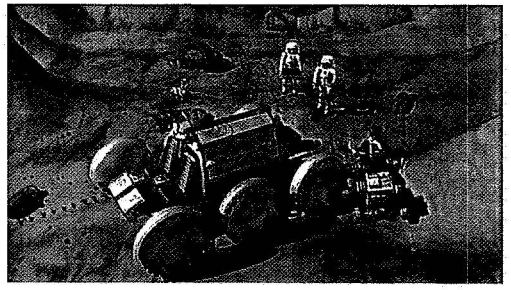


# The Moon – the First Step to Mars and Beyond....

- **Gaining significant experience in operating away from Earth's environment**
  - Space will no longer be a destination visited briefly and tentatively
  - "Living off the land"
  - Human support systems



- **Developing systems needed for opening the space frontier**
  - Crew and cargo launch vehicles (125 metric ton class)
  - Earth ascent/entry system – Crew Exploration Vehicle
  - Mars ascent and descent propulsion systems

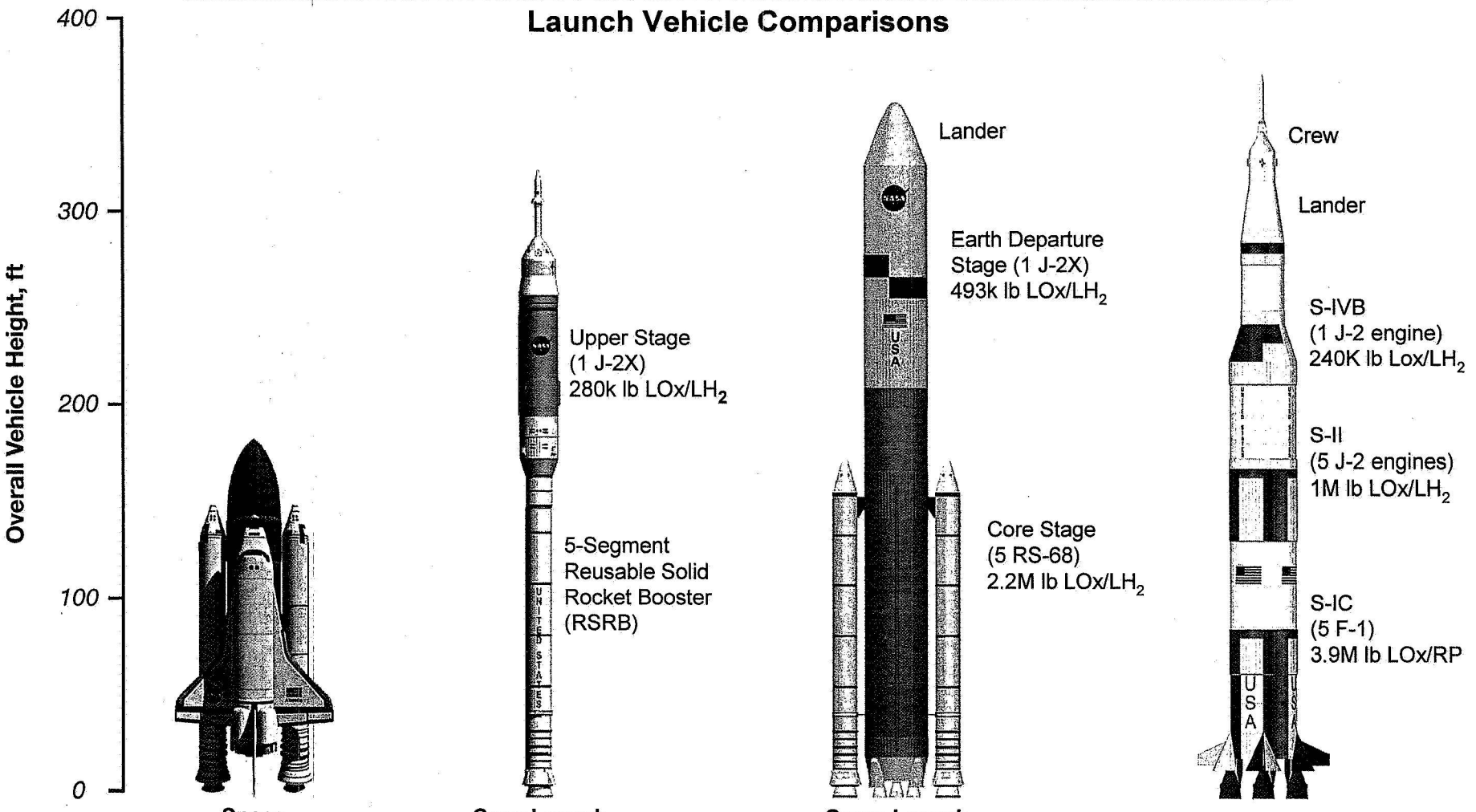


- **Conducting fundamental science**
  - Astronomy, physics, astrobiology, historical geology, exobiology

***Next Step in Fulfilling Our Destiny As Explorers***

# Building on a Foundation of Proven Technologies

## Launch Vehicle Comparisons




**Space Shuttle**

**Height:** 184.2 ft
**Gross Liftoff Mass:** 1.7M lb

55k lbm to LEO

**Crew Launch Vehicle**

**Height:** 321 ft
**Gross Liftoff Mass:** 2.0M lb

55k lbm to LEO

**Cargo Launch Vehicle**

**Height:** 358 ft
**Gross Liftoff Mass:** 6.4M lb

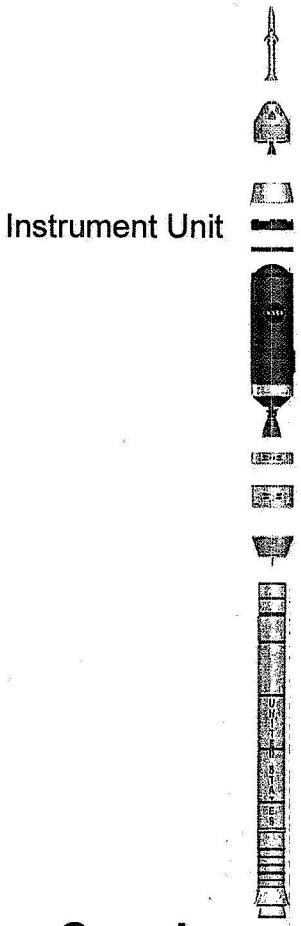
121k lbm to Trans-Lunar Injection (TLI)
147k lbm to TLI in Dual-Launch Mode with CLV

**Saturn V**

**Height:** 364 ft
**Gross Liftoff Mass:** 6.5M lb

121k lbm to LEO

# Constellation Launch Vehicle Elements



LAS

Crew Exploration Vehicle (CEV)
(Crew Module / Service Module)

Instrument Unit

Spacecraft Adapter

Forward Skirt

Upper Stage

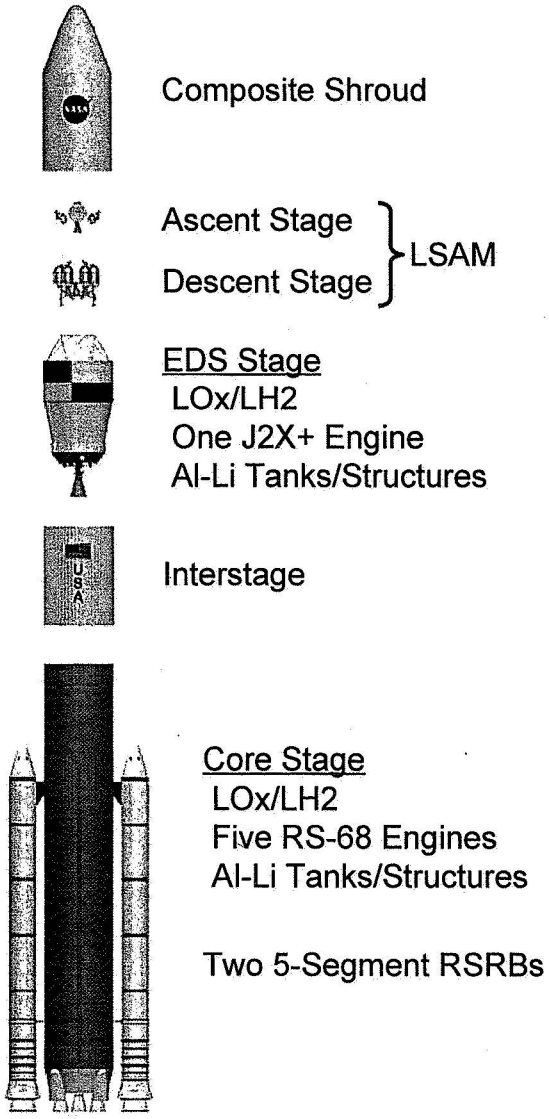
J-2X Upper Stage Engine

Interstage

Forward Frustum

First Stage
(5-Segment Reusable Solid Rocket Booster (RSRB))

**Crew Launch Vehicle**



Composite Shroud

Ascent Stage
Descent Stage
} LSAM

EDS Stage
LOx/LH2
One J2X+ Engine
Al-Li Tanks/Structures

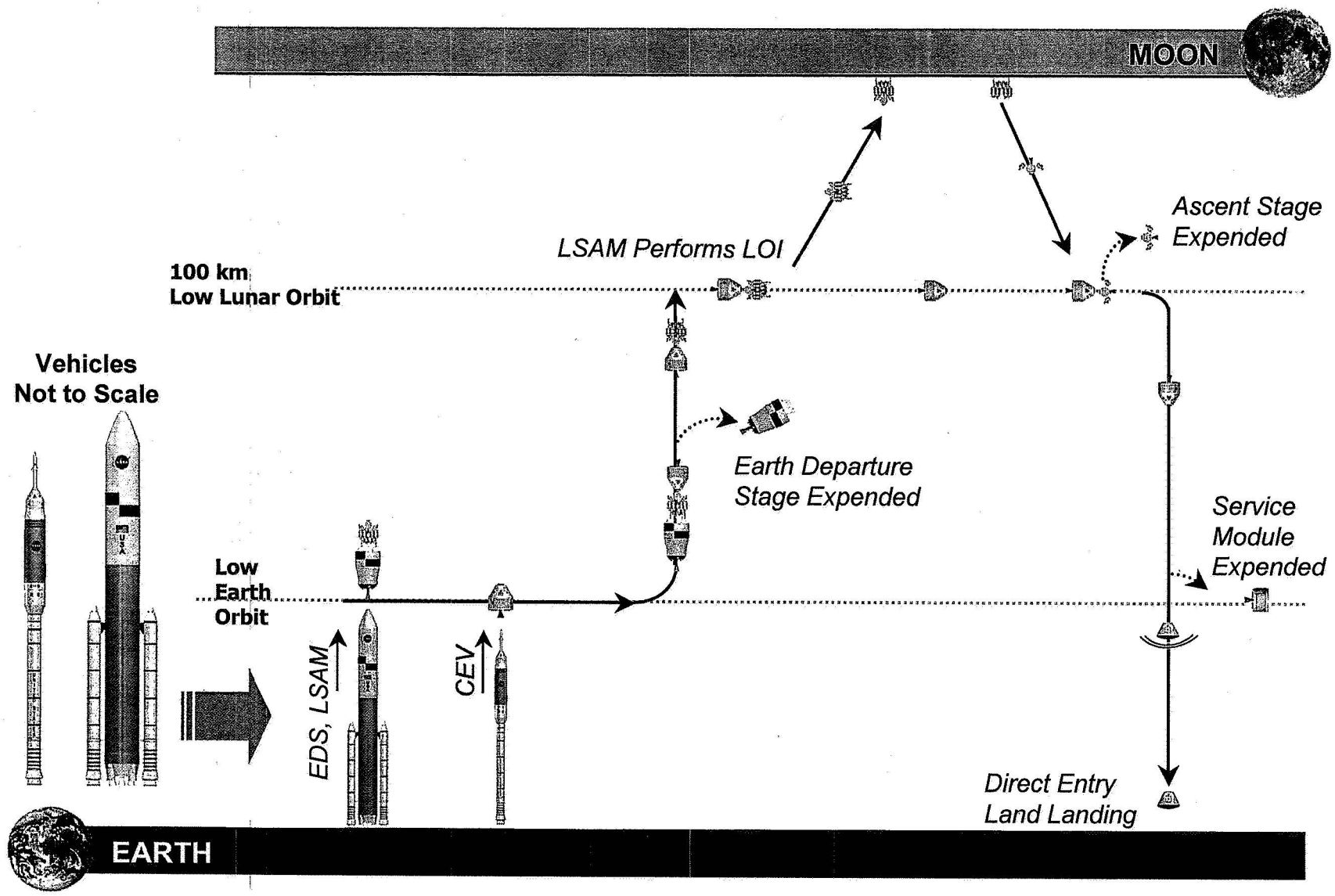
Interstage

Core Stage
LOx/LH2
Five RS-68 Engines
Al-Li Tanks/Structures

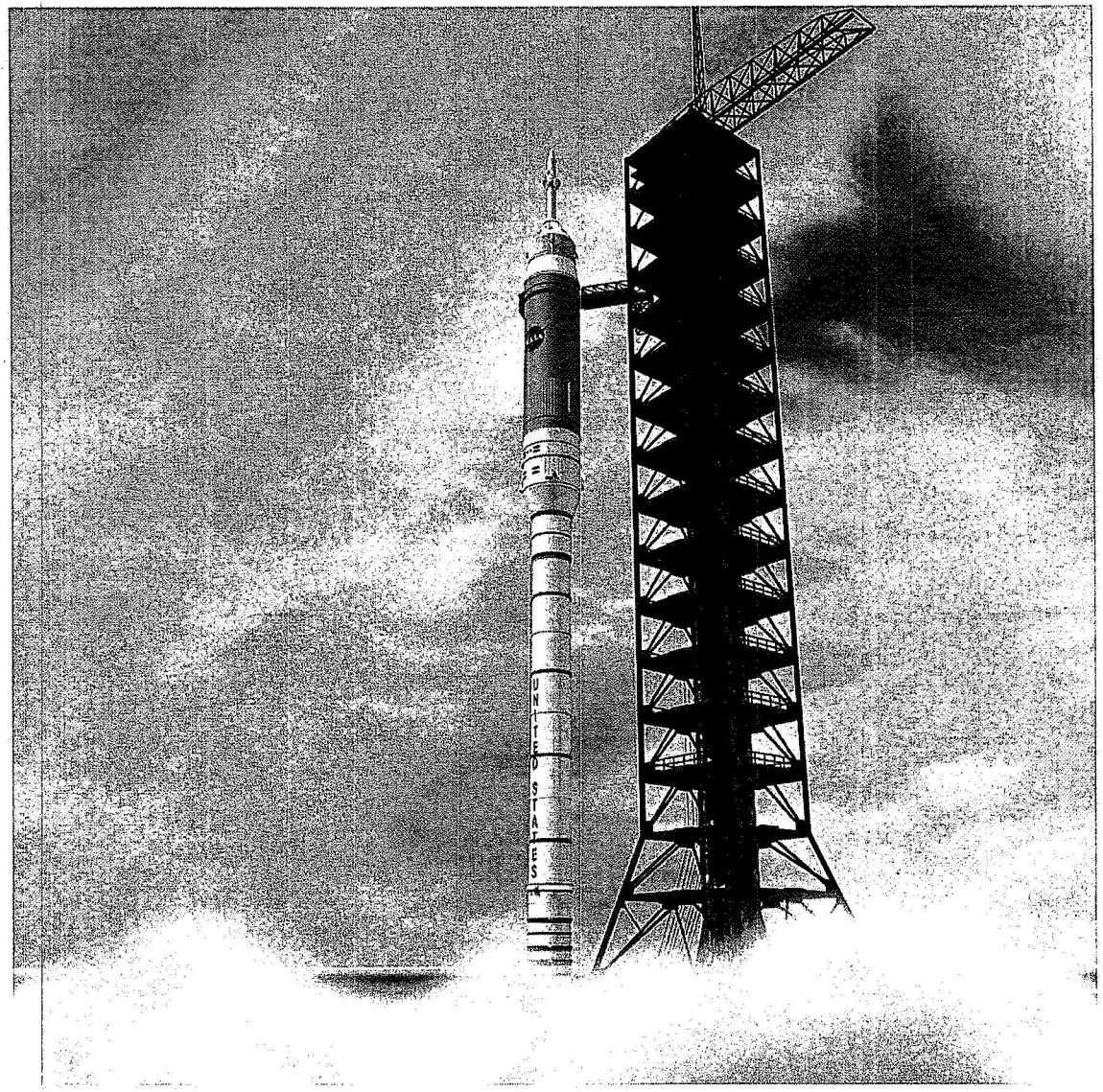
Two 5-Segment RSRBs

**Cargo Launch Vehicle**

# "1.5 Launch" Earth Orbit / Lunar Orbit Rendezvous

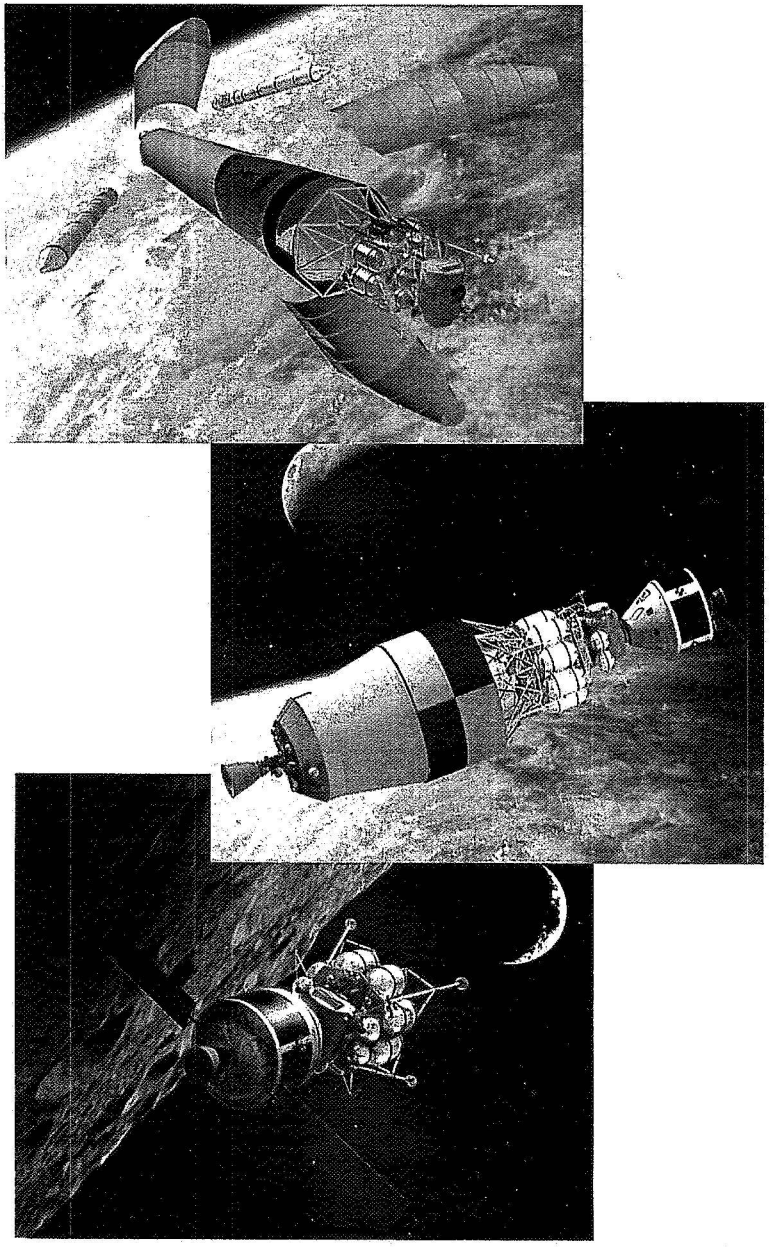


# The Journey Continues . . .



# Design Philosophy for Mission Success

- **Keep it simple.**
  - Minimize complexity and interactions.
  - Simplify interfaces.
  - Make it robust.
- **Focus on reliability, maintainability and supportability early to improve safety and reduce operations costs.**
- **Apply rigorous systems engineering, including validated engineering tools, models, and process to new vehicle configurations.**
- **Apply Lessons Learned**



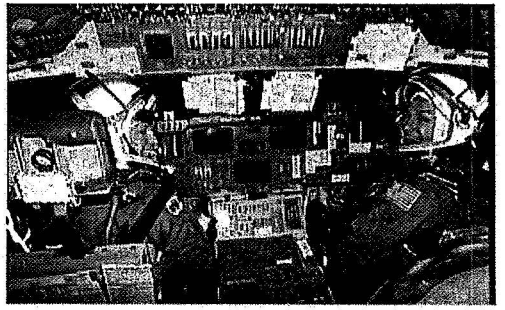
# Lessons Learned: Implementation Tenets

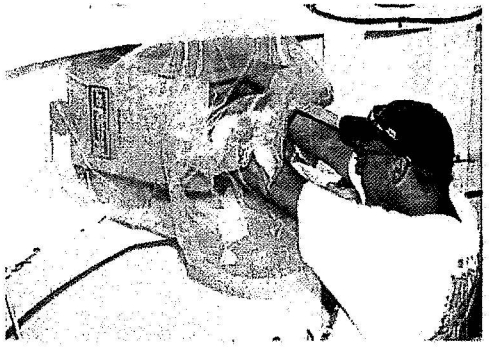



- **Utilize current, proven technology.**
- **Constantly look for ways to drive costs down and out—non-recurring and recurring.**
- **"Zero-Based" approach**
  - Question everything—Requirements must earn their way in
- **Performance-based contracting**
  - Incentivize.
  - Specify the desired outcome.
  - Scrub Design Reference Documents (DRDs) to limit to only what the U.S. Government (USG) can review/use. Must prove to be useful.
  - Focus on milestone objectives, not just default, periodic meetings/reports.
  - Be milestone specific—tell them what we want, how much, how often, etc. Do not be open-ended.
  - Allow contractors to use commercial practices as much as possible, yet ensure a safe system
  - Do not reference lists of NASA Procedural Requirements (NPRs)—say what we want.
- **Leverage Apollo, Shuttle, and Evolved Expendable Launch Vehicles knowledge and experience.**

# Lessons Learned: Early Integration with the Operators

- **Astronaut Crew office is an active participant in Constellation Launch Vehicles activities**
- **KSC and JSC co-chair CLV Operations Development Group to ensure operators influence on requirements and Design**
- **Operability & supportability must be designed into the system and culture upfront**
  - Reduction of fixed operations cost essential
- **Effort must be requirements-driven—Two key CLV Ops requirements**
  - Launch availability – probability of meeting launch date and launch window
  - Recurring cost (fixed and variable)
- **Allocate recurring cost requirements in the proper form to the lowest level components**

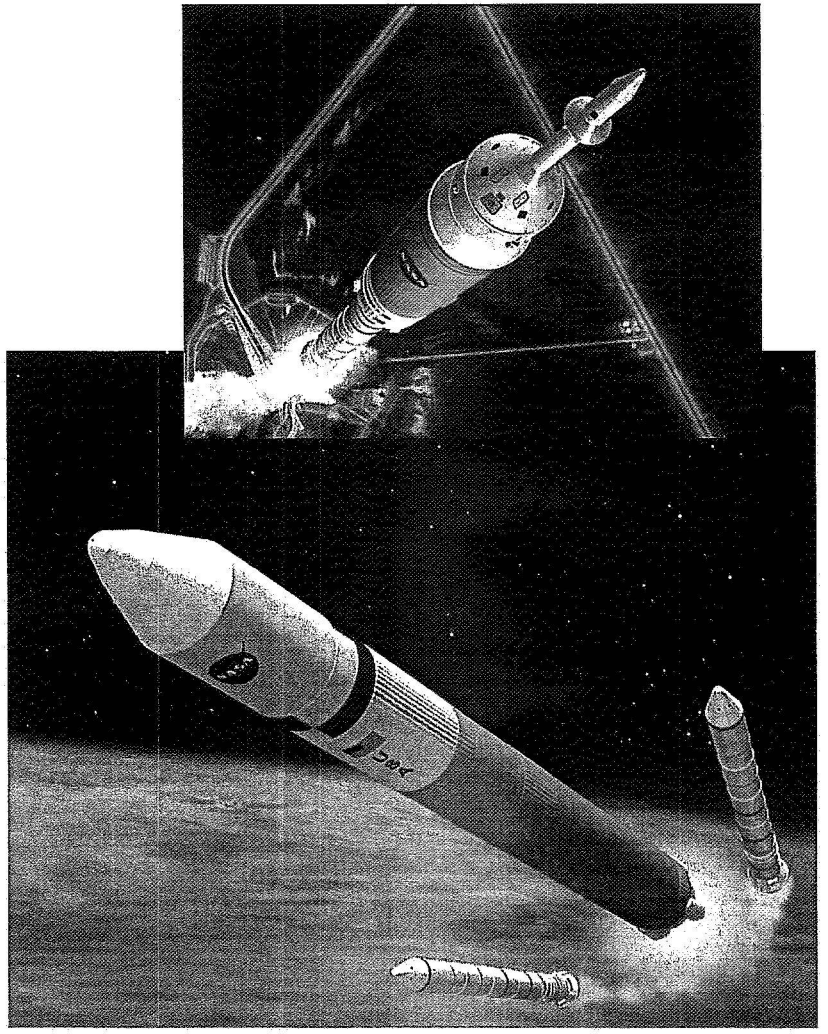


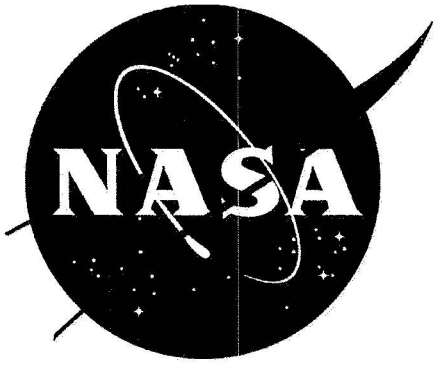




# Summary

- Build beyond our current capability to ferry astronauts and cargo to low Earth orbit.
- Steps will be evolutionary, incremental, and cumulative.
- To reach for Mars and beyond we must first reach for the Moon.
- Team is on board and making good progress.
- Utilizing extensive lessons learned to minimize cost, technical, and schedule risks.






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